

MACHINE LEARNING BASED CHARACTERIZATION OF NANOINDENTATION INDUCED ACOUSTIC EVENTS

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Developed as Baushinger effect monitoring technique in polycrystalline metallic materials the passive acoustic wave monitoring has been a critical health monitoring technique in Atomic energy pressurized tanks, power and structure monitoring in aeronautics, automotive, as well as recent application in spinning disk data storage (HDD) health monitoring applications [1]. Passive monitoring of acoustic waves generated during initial contact point has been attracting attention of material scientists since the inception of nanomechanical test instruments for nanoindentation and nanoscratch applications. The conventional acoustic wave signal treatment via RMS or integrated energy values proved that quantitative acoustic wave properties correlate well with the local contact materials phenomena such as yield point initiation for W(100) [2, 3], Sapphire [4], phase transformation for SMA [2] and differentiating of thin film fracture modes [5]. Several attempts have been made to look at the differentiative properties of the acoustic signatures via signal decomposition techniques such as wavelets [2, 6]. Even though acoustic wave signatures were reconstructed, the true potential of the method was not investigated from the machine learning perspective. In this work a machine learning based signal processing of nanoindentation induced acoustic events was investigated in details. The synergy of wavelet signal decomposition and information theory based signal presorting prepares data for the machine learning step. In the machine learning step the Bayesian filtering and convolutive neural networks sort wavelet coefficients by their statistical significance. This creates acoustic signature libraries that are typical for the specific materials phenomena during the indent. The hardware consist of the newly developed ultrasonic probe integrated into the nanoindentation tip, thus eliminating boundary effects and ensuring that only waves that pass via the contact are being recorded. Appropriate signal conditioning and fast data acquisition hardware is synchronized with a quasi-static nanoindentation controller. The machine learning routine together with wavelet decomposition and presorting algorithms are implemented into the dedicated acoustic data evaluation kernel which resides in the fast access memory of the designated controller.

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